SPECIFICATION

# PACKING

Add A01

## Field of the Invention

~~Technical Field~~

The present invention relates to packing suitably used as gland packing to be used at a shaft sealing portion in a fluid apparatus.

## Background of the Invention

~~Art~~

As the material of a gland packing used at, for example, a shaft sealing portion in a fluid apparatus or the like, there is known a material using, as its base material, expanded graphite excellent in compression-restoring force and sealing properties.

The gland ~~Gland~~ packing of such material is made by a compression molding method of the laminate type, the die molding type, the tip molding type, the ribbon pack type, or the like. Such gland packing should be previously made in the form of a ring having an inner diameter corresponding to the outer diameter of a shaft to be sealed. Accordingly, the gland packing cannot be used for a shaft of which the outer diameter is not fit for the inner diameter of the ring-like packing. Thus, such packing lacks versatility. Further,

the expanded graphite itself is poor in tensile strength and therefore fragile. This makes it difficult to take out, for replacement, such gland packing which has been mounted on a stuffing box or the like. Thus, the gland packing presents a problem in view of practical utility.

In addition, the respective types of the compression molding present the following problems.

In the laminate-type, the yield is low, leading to increase in production cost. In the die molding type and the tip molding type, gland packing is molded with the use of molds, causing the production cost to be increased. Further, such gland packing lacks versatility. The ribbon pack type presents poor workability.

The problems ~~above-~~mentioned above may be solved by making the expanded graphite ~~in~~ the form of a string or braided packing, so that the ~~string-like expanded~~ graphite may be used as cut into a predetermined length according to the diameter of a shaft to be sealed. ~~Likewise braided packing~~. However, the expanded graphite itself comprises vermiform ~~is apparently caterpillar-like~~ particles, each of which is expanded in the direction of the C-axis of the crystal of a graphite particle. These vermiform ~~caterpillar-like~~ particles as agglomerated may be compression-molded into a

sheet. However, the expanded graphite even made in such a sheet, is poor in tensile strength and therefore fragile. Accordingly, such a sheet cannot be cut into yarn, ~~with the use of which~~ suitable to make a braided body ~~is to be made~~. It is therefore not possible to apply such expanded graphite to a packing which may be used as cut to a predetermined length according to the diameter of a shaft to be sealed and wound around the outer periphery thereof, ~~likewise~~ a braided packing.

## ~~Disclosure~~ Summary of the Invention

In view of the background art ~~above~~ mentioned above, an object of the present invention is ~~proposed with the object of~~ to provid~~ing~~e packing in the form of a string improved in practical utility and versatility. After ~~hard~~ diligent study of the arrangement of a ~~knitting~~ braiding yarn using expanded graphite, ~~the inventor~~ a way has been found ~~a way~~ to make a ~~knitting~~ braiding yarn of expanded graphite by bonding expanded graphite to a reinforcing fiber yarn with adhesives, so that the synergistic action of the reinforcing fiber yarn and the expanded graphite gives, to the resultant ~~knitting~~ braiding yarn, a great compression-restoring force, excellent sealing properties, and strong tensile strength and toughness. A plurality of such ~~knitting~~ braiding yarns may be put together to form a core mem-

ber and the core member may be then covered, at the outer periphery thereof, with a braided body of the braiding ~~knitting~~ yarns, thereby to make the assembly in the form of a string. A plurality of such braiding ~~knitting~~ yarns as put together may be braided in the form of a string. A plurality of such braiding ~~knitting~~ yarns as put together may also be twisted in the form of a string.

According to the packing of the present invention, the strong tensile strength and toughness of the reinforcing fiber yarns are given to the braiding ~~knitting~~ yarns. Thus, the braiding ~~knitting~~ yarns may be braided or twisted without the yarns cut. It is therefore possible to form a string-like packing in which the core member made of the braiding ~~knitting~~ yarns is covered, at the outer periphery thereof, with a braided body of the braiding ~~knitting~~ yarns. Further, the great compression-restoring force and excellent sealing properties of the expanded graphite are given to the core member and the braided body, thus assuring such sealing properties as inevitably required for packing.

Further, a plurality of such braiding ~~knitting~~ yarns provided with strong tensile strength and toughness may be put together and braided. It is therefore possible to form a braided body (as square-knitted) having strong tensile strength and toughness. The great com-

pression-restoring force and excellent sealing properties of the expanded graphite are given to the braided body, thus assuring such sealing properties as inevitably required for packing.

Further, a plurality of such braiding ~~knitting~~ yarns having strong tensile strength and toughness may be put together and twisted. It is therefore possible to form a twisted string-like member having such strong tensile strength and toughness. In addition, the great compression-restoring force and excellent sealing properties of the expanded graphite are given to this string-like member, thus assuring such sealing properties as inevitably required for packing.

## Brief Description of Drawings

Figure 1 is a perspective view, with portions broken away, of an embodiment of a packing in accordance with a first variant of the invention;

Figure 2 is a perspective view, with portions broken away, of an example of a braiding ~~knitting~~ yarn;

Figure 3 is a perspective view of an embodiment of packing in accordance with a second variant of the invention;

Figure 4 is a perspective view of an embodiment of packing in accordance with a third variant of the invention;

Figure 5 is a perspective view of another exam-

ple of the braiding ~~knitting~~ yarn;

Figures 6 to 10 are views of various examples of a reinforcing fiber yarn; and

Figures 11A, 11B and Figures 12A, 12B are views illustrating variations of the distances between braiding ~~knitting~~ yarns fed from bobbins and a knitting point in circular knitting and square knitting, respectively.

## ~~Best Mode for Carrying Out the Invention~~

Fig. 1 is a perspective view, with portions broken away, of an embodiment of a packing in accordance with a first aspect of the invention.

In Fig. 1, packing 1 comprises a core member 2 and a braided body 3 covering the outer periphery of the core member 2, the braided body 3 being made by, for example, circular-knitting. The core member 2 is formed by longitudinally arranging a plurality of ~~knitting~~ braiding yarns 4 as put together. The internally reinforced braided body 3 is formed by circular-~~knitting~~ braiding the ~~knitting~~ braiding yarns 4.

As shown in Fig. 2, each ~~knitting~~ braiding yarn 4 comprises a plurality of longitudinally arranged reinforcing fiber yarns 40 made of, for example, cotton, and ~~caterpillar-like~~ having a vermiform shape expanded graphite 41, integrally bonded to ~~both~~ the outer surfaces of the yarns 40 with adhesives

(for example, acrylic ester) (not shown).

The cotton yarns used as the reinforcing fiber yarns 40 have, on the outer surfaces thereof, an infinite number of extremely short and fine fibers, i.e., so-called fuzz. This improves the adhesion of the adhesives. Accordingly, the reinforcing fiber yarns 40 and the expanded graphite 41 are securely bonded to each other to prevent the expanded graphite 41 from partially falling from the reinforcing fiber yarns 40.

Thus, the braiding ~~knitting~~ yarns 4 are formed by integrally bonding, with adhesives, the expanded graphite 41 to the outer ~~both~~ surfaces of a plurality of longitudinally arranged reinforcing fiber yarns 40 made of, for example, cotton. The strong tensile strength and toughness of the reinforcing fiber yarns 40 are given to the ~~knitting~~ braiding yarns 4. Accordingly, the braiding ~~knitting~~ yarns 4 may be braided without the yarns 4 being cut. It is therefore possible to form a string-like member 5 in which the outer periphery of the core member 2 made of the ~~knitting~~ braiding yarns 4 is covered with the braided body 3 as obtained by circular ~~knitting~~ braiding the ~~knitting~~ braiding yarns 4. This string-like member 5 has characteristics excellent in tensile strength and toughness. Thus, this string-like member 5 may be used, as the packing 1, as cut to a predetermined length according to, for exam-

ple, the diameter of a shaft to be sealed. This improves the packing 1 in versatility and practical utility. Further, the great compression-restoring force and excellent sealing properties of the expanded graphite 41 are given to the core member 2 and the braided body 3 forming the packing 1. It is therefore assured that the packing 1 is provided with such excellent sealing properties as inevitably required for packing.

Fig. 3 is a perspective view of an embodiment of packing in accordance with a second variant of the invention. In Fig. 3, like parts are designated by like numerals used in Fig. 1 and the detailed description of such like parts is here omitted.

In Fig. 3, the packing 1 is made in the form of a string-like member 5 made of a braided body 3A as obtained by square ~~braiding~~ internally reinforced braiding ~~knitting~~ eight yarns 4.

The strong tensile strength and toughness of reinforcing fiber yarns 40 are given to the ~~knitting~~ braidings yarns 4. Accordingly, the ~~knitting~~ braiding yarns 4 may be braided (as square-knitted) without the yarns 4 cut. Thus, the string-like member 5 may be made of the braided body 3A having characteristics excellent in tensile strength and toughness. It is therefore pos-

sible to use, as the packing 1, this string-like member 5 as cut to a predetermined length according to, for example, the diameter of a shaft. This improves the packing 1 in versatility and practical utility. Further, the strong compression-restoring force and excellent sealing properties of the expanded graphite 41 are given to the braided body 3A forming the packing 1. Accordingly, the packing 1 may be provided with such sealing properties as indispensably required for packing.

Fig. 4 is a perspective view of an embodiment of packing in accordance with a third variant of the invention. In Fig. 4, like parts are designated by like numerals used in Fig. 1 and the detailed description of such like parts is here omitted.

In Fig. 4, the packing 1 is made in the form of a string-like member 5 by roll-molding six ~~knitting~~ braiding yarns 4 formed as described above ~~as bound~~ while these ~~knitting~~ braiding yarns 4 are being twisted 20 times/m.

The strong tensile strength and toughness of the reinforcing fiber yarns 40 are given to the ~~knitting~~ braiding yarns 4. Accordingly, the ~~knitting~~ braiding yarns 4 may be twisted without the yarns 4 cut. It is therefore possible to form the string-like member 5 having strong tensile strength and toughness. Accordingly, this

string-like member 5 may be used, as the packing 1, as cut to a predetermined length according to, for example, the diameter of a shaft to be sealed. This improves the packing 1 in versatility and practical utility. Further, the strong compression-restoring force and excellent sealing properties of the expanded graphite 41 are given to the twisted string-like member 5 forming the packing 1. Accordingly, the packing 1 may be provided with such sealing properties as indispensably required for packing.

In the foregoing, the description has been made of ~~the~~ expanded graphite 41 in vermiform shaped ~~the form of caterpillar-like~~ particles. Alternately, there may be used expanded graphite sheets each of which is so cut as to have a small width of, for example, 5 mm or less.

Alternately, each braiding ~~knitting~~ yarn 4 may be formed by bonding the expanded graphite 41 only on one side surface of a plurality of reinforcing fiber yarns 40 with adhesives.

Further, the braiding ~~knitting~~ yarns 4 may be used after twisted as shown in Fig. 5.

The reinforcing fiber yarns 40 forming the braiding ~~knitting~~ yarns 4 may be made of, instead of cotton mentioned earlier, a single material which is selected from organic fibers such as rayon fibers, phenol fi-

bers, aramid fibers, PBI (polybenzimidazole) fibers, PTFE (polytetrafluroethylene) fibers, PPS (polyphenylene sulfide) fibers, PEEK (polyether ether ketone) fibers and the like, which is selected from inorganic fibers such as glass fibers, carbon fibers, ceramic fibers and the like, or which is selected from metallic line members such as line members of stainless steel, Inconel, monel metal and the like.

The inorganic fibers and the metallic line members present no fuzz on the surfaces thereof, and are therefore slightly inferior in adhesion to ~~of~~ the adhesives to the organic fibers. However, the proper selection of the adhesives enables the reinforcing fiber yarns 40 and the expanded graphite 41 to be bonded to each other in a relatively secure manner. This prevents the expanded graphite 41 from partially falling from the reinforcing fiber yarns 40. In the ~~knitting~~ braiding yarns 4 made of such inorganic fibers or metallic line members, the tensile strength is considerably improved as compared with the ~~knitting~~ braiding yarns 4 made of the organic fibers.

Figs. 6 to Fig. 10 respectively show modifications of the reinforcing fiber yarn 40.

In Fig. 6, the reinforcing fiber yarn 40 is made by twisting a yarn 40A made of a single material selected from the organic fibers mentioned earlier (cotton or aramid), and a yarn 40B made of a single

material selected from the inorganic fibers and metallic line members mentioned earlier (glass fibers, carbon fibers or stainless steel line members). This reinforcing fiber yarns 40 may be improved in toughness and adhesion of adhesives by the organic fibers, and also improved in tensile strength and toughness by the inorganic fibers or metallic line members.

In Fig. 7, the reinforcing fiber yarn 40 comprises (i) a yarn 40B made of at least one material selected from the inorganic fibers and metallic line members mentioned earlier (glass fibers, carbon fibers or stainless steel line members), and (ii) short fibers 6 made of a single material selected from the organic fibers mentioned earlier (cotton or aramid), the short fibers 6 covering the surface of the yarn 40B. This reinforcing fiber yarn 40 may be improved in toughness and adhesion of adhesives by the covering layer of the short fibers 6, and also improved in tensile strength and toughness by the yarn 40B made of at least one material selected from the inorganic fibers and the metallic line members. The short fibers 6 forming the covering layer may be made of a composite short fiber yarn containing, in combination, fibers made of two or more types selected from the organic fibers.

In Fig. 8, the reinforcing fiber yarn 40 comprises a yarn 40B made of at least one material selected from the inorganic fibers and metallic line members mentioned earlier (glass fibers, carbon fibers or stainless steel line members), this yarn 40B being covered with, for example, pulp sheet-form 7. This reinforcing fiber yarn 40 may be improved in toughness and adhesion of adhesives by the covering layer of the pulp sheet-form 7, and also improved in tensile strength and toughness by the yarn 40B made of at least one material selected from the inorganic fibers and the metallic line members.

In Fig. 9, the reinforcing fiber yarn 40 is made by knitting either a yarn 40A made of a single material selected from the organic fibers mentioned earlier (cotton or aramid) or a yarn 40B made of a single material selected from the inorganic fibers and metallic line members mentioned earlier (glass fibers, carbon fibers or stainless line members). This reinforcing fiber yarn 40 may be improved in adhesion of adhesives by the concavo-convex knitted portions in the knit structure thereof. Further, the stretching properties of the knit structure itself may absorb a tensile force. This results in increase in tolerance for stretching, thus improving ~~the~~ toughness.

In Fig. 10, the reinforcing fiber yarn 40 comprises (i) a plurality of longitudinally arranged fibers 40B in parallel to one another, made of a single material selected from the inorganic fibers and metallic line members mentioned earlier (glass fibers, carbon fibers or stainless steel line members), and (ii) fibers 40A made of a single material selected from the organic fibers mentioned earlier (cotton or aramid), the fibers 40A being entangled with the fibers 40B so that the fibers 40B are maintained in parallel with one another. This reinforcing fiber yarn 40 may be improved in toughness and adhesion of adhesives by the organic fibers, and also improved in tensile strength and toughness by the inorganic fibers or the metallic line members.

The strong tensile strength and toughness of the reinforcing fiber yarns 40 are given to the braiding ~~knitting~~ yarn 4. Thus, the braiding ~~knitting~~ yarns 4 may be readily braided or twisted without the yarns 4 cut. More specifically, when carrying out circular-knitting while drawing out the braiding ~~knitting~~ yarns 4 from a plurality of bobbins 9 adapted to be moved along loci shown by broken lines as shown in Figs. 11A and 11B, there is produced a small difference between the distance la between a knitting point P and each pf the bobbin 9 as

located in the outermost ~~mostouter~~ parts of one locus, and the distance 1b between the knitting point P and each of the bobbins 9 as located in the innermost ~~mostinner~~ parts of the other locus. In this case, a relatively small tensile force is applied to the braiding ~~knitting~~ yarns 4, so that the yarns 4 may be readily braided. On the other hand, when carrying out square-knitting while drawing out the braiding ~~knitting~~ yarns 4 from a plurality of bobbins 9 adapted to be moved along diagonal loci shown by broken lines as shown in Figs. 12A and 12B, there is produced a great difference between the distance 1a between a knitting point P and each of the bobbins 9 as located in the outermost ~~mostouter~~ parts of one locus, and the distance 1b between the knitting point P and each of the bobbins 9 as located in the center parts of the other locus. In this case, a relatively great tensile force is applied to the braiding ~~knitting~~ yarns 4. Even in this case, the yarns 4 may be braided.

## Industrial Applicability

In packing using expanded graphite as a base material, the present invention eliminates a need for provision of a variety of annular packings according to the diameters of shafts to be sealed, as conventionally required for molded packing made of expanded

graphite. The packing of the present invention has not only such sealing properties as inevitably required for packing, but also strong tensile strength and toughness. Thus, the packing of the present invention may be suitably used as gland packing or a sealing member for static members.